Fine Scale Baleen Whale Behavior Observed Via Tagging Over Daily Time Scales

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LONG-TERM GOALS

Tagging studies of cetaceans have focused primarily on two disparate time scales: short (hours) or long (weeks to months). Studies using sensor-rich suction-cup tags, focal follows, and proximate environmental sampling provide highly detailed observations of behavior that can be interpreted in the context of conspecific behavior, oceanographic conditions and prey distribution; however, tag attachment durations are typically short (hours) and sustained tracking and environmental sampling from small vessels is logistically challenging. Longer-term tagging studies using implanted satellite tags can provide location data over periods of weeks to months; however, inferences about behavior at time scales of hours to days are difficult to make with the limited sensor data returned by the tags and the low rate at which location data are provided (typically only 1-2 locations per day). While studies at both short and long time scales are enormously beneficial, there is also a critical need to understand cetacean behavior at intermediate daily time scales. Recent efforts to assess the impacts of sound on marine mammals and to estimate foraging efficiency have called for the need to measure daily activity budgets to quantify how much of each day an individual devotes to foraging, resting, traveling, or socializing. Moreover, many conservation issues require an understanding of daily diving activity (e.g., how much time each day does an individual spend near the bottom, at depth, in a sound channel, or at the surface?). Finally, several studies have observed diel trends in calling behavior or prey distribution that suggest diel variability in cetacean behavior; hypotheses about diel patterns in behavior can only be addressed definitively with tagging studies over daily time scales.

My long-term goal is to develop a tagging and tracking system that will allow cetaceans to be followed over time scales of days from an oceanographic vessel so that environmental sampling can be conducted in proximity to the tagged whale. Analyses of diving and movement behavior from the tagging and tracking data could then be combined with observations of oceanographic conditions and prey distribution to elucidate the environmental factors that influence both behavior and distribution over daily time scales.

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OBJECTIVES

My objectives are (1) to develop a reliable tagging and tracking system that allows sustained unambiguous tracking over time scales of days, and (2) to characterize the relationship between diel variability in the foraging behavior of baleen whales (North Atlantic right whales and sei whales) and the diel vertical migration behavior of their copepod prey. I hypothesize that (1) right whales track the diel vertical migration of copepods by feeding near the bottom during the day and at the surface at night, and (2) sei whales are unable to feed on copepods at depth during the day, and are therefore restricted to feeding on copepods at the surface only. Because copepod diel vertical migration is variable over time (days to weeks) and space (tens of kilometers) (Baumgartner et al. 2011), I further hypothesize that sei whales range much further than right whales to find areas where copepods are exhibiting weak diel vertical migration behavior.

APPROACH

Most tracking studies rely on radio or acoustic transmitters incorporated in the animal-borne tag to provide a homing signal. Radio waves do not penetrate seawater, so opportunities to locate an animal carrying a radio transmitter are limited to very short periods when the animal is at the surface and the tag is exposed to air. Acoustic transmitters allow continuous tracking while an animal is submerged, but the reception range of a high-frequency transmitter (~30 kHz) is limited to 1-2 kilometers at most. While both of these tracking methods provide bearing from the tracking vessel to a tagged animal, neither provides accurate range measurements, so location estimation is ambiguous. In practice, these methods rely strongly on establishing visual contact with the tagged animal to verify its true location. Because visual contact requires daylight, these methods are far less effective during the night. Moreover, tracking via a homing signal is labor intensive and exhaustive, and is therefore difficult to maintain with great accuracy for tens of hours.

To accomplish sustained tracking over daily time scales, two innovations are required: (1) a reliable tag attachment that lasts for more than one day, and (2) an unambiguous tracking capability that does not rely on visual contact. For studies of baleen whale ecology, we have developed a dermal attachment that is implanted into the skin and blubber of a whale and acts as a short-term anchor for carrying tags for periods of hours to days (Baumgartner and Hammar 2010). We are combining this new attachment with a commercially available archival tag (MK10-PATF; Wildlife Computers) to allow real-time tracking via a FastLoc GPS receiver and an ARGOS radio transmitter integrated in the whale-borne tag. Every 5-15 minutes, FastLoc GPS data collected during the tagged whales' surfacings will be telemetered from the tag to a local ARGOS receiver aboard an oceanographic vessel where the whales' position will be calculated and displayed to allow both daytime and nighttime tracking (Figure 1). This precise tracking ability will allow the ship to continuously remain in proximity to the whale so that it can collect both behavioral, oceanographic, and prey observations.

WORK COMPLETED

During the fall of 2012 and winter of 2013, WHOI engineer Terry Hammar and I iterated on a design for the attachment, using the dermal anchor in a spring-loaded mechanism that would allow the tag to fly straight when fired from a compressed-air launcher (Figure 2a), but to sit perpendicular to the whale's skin when it attached (Figure 2b). The final design actually kept the tag lifted off the skin so that the only contact between the entire tag and the whale's skin was the dermal anchor (Figure 2b). We finalized the design in mid-April 2013 and created 5 attachment mechanisms in preparation for the

first leg of our May 2013 cruise (see below). We also fabricated matching carrier rockets (Figure 2c), and had 2 new barrels fabricated by ResTech (the manufacturer of the compressed-air launcher) to accommodate the new tag. We purchased two Wildlife Computers MK10-PATF tags and modified them so that the attachment mechanism could be rigidly connected to the tag (Figure 2).

Also during the fall of 2012 and winter of 2013, I worked with Dr. Ed Bryant (Wildtrack Telemetry Systems, Ltd) to set up the system used to acquire, decode, and display FastLoc data acquired from the Wildlife Computers MK10-PATF tag. An AOR AR8200 wideband radio receiver, ublox GPS, and a BlackBox KVM extender were housed inside a weather-proof box (Figure 2d) so that they could be mounted on the mast of a NOAA vessel. A BlackBox extender allowed both the audio from the radio receiver and the serial output of the GPS to be sent via 150 ft. of Cat5e Ethernet cable from the mast to a computer lab on the ship. A laptop PC was set up with Ed's software to decode incoming ARGOS messages received by the antenna on the mast, and calculate and display the FastLoc GPS data.

In April 2013, I met with Wildlife Computers in Redmond, Washington to present my research and discuss this project. They offered to loan me a system that functioned identically to the one Ed Bryant had supplied, called spicyTalk. The advantage of their system, they explained, was that their receiver was tuned specifically for their tags and decoding was done directly from the received ARGOS signal (as opposed to the Bryant system, where decoding is done from the audio signal produced by the wideband radio receiver). I happily took spicyTalk, packaged it in a waterproof box, and used it alongside Ed's system to do a comparison between the two. While at Wildlife Computers, I also asked for and they kindly provided a small change in how their MK10-PATF tag reports FastLoc GPS data through the ARGOS messages. Subsequent lab and shipboard tests indicated that the two receiving systems (Ed Bryant's and spicyTalk) were capable of receiving ARGOS messages, decoding the FastLoc data, and calculating a position for the tag, but the spicyTalk system was much more reliable. The Bryant system would often miss ARGOS transmissions, whereas the spicyTalk system was adept at receiving and decoding nearly every ARGOS transmission. Given that a whale-borne tag would not have many opportunities to transmit, this difference in reliability was quite important.

In May 2013, I participated in the annual NOAA NEFSC large whale cruise to the Great South Channel to tag right and sei whales with the new tag. Both the Bryant and the spicyTalk receivers were mounted on the high mast of the NOAA Ship Gordon Gunter, and both systems used BlackBox KVM extenders to route data to the ship's computer lab via Cat5e cables. Despite our being very ready to deploy the tags, and despite our best efforts to find whales, we were unable to even attempt to tag whales because of poor weather and very low abundance of whales. We spent a total of 24 days at sea, and we only deployed our small boat on one occasion to approach whales; on that single day, we spent very little time on the water because the wind increased substantially after we launched, so we had to recover shortly thereafter. This was a great surprise and disappointment to me, as I have been working in the Great South Channel nearly every year since 2004, and we have never had this much difficulty finding whales to tag.

We will participate in the NOAA NEFSC large whale cruise again next May (spring 2014), and I will try again to tag whales using exactly the same equipment that was prepared for the 2013 cruise.

RESULTS

No scientific results are available at this time. Engineering results are described above.

IMPACT/APPLICATIONS

This work will directly help efforts to mitigate the effects of anthropogenic activities on baleen whales by characterizing (1) daily activity budgets, (2) where in the water column whales feed both day and night, and (3) the relationship between physical processes, prey distribution, and whale behavior. Ultimately, our ability to predict or even forecast whale distribution will hinge on a fundamental understanding of foraging behavior and how that behavior varies with changes in prey behavior and distribution.

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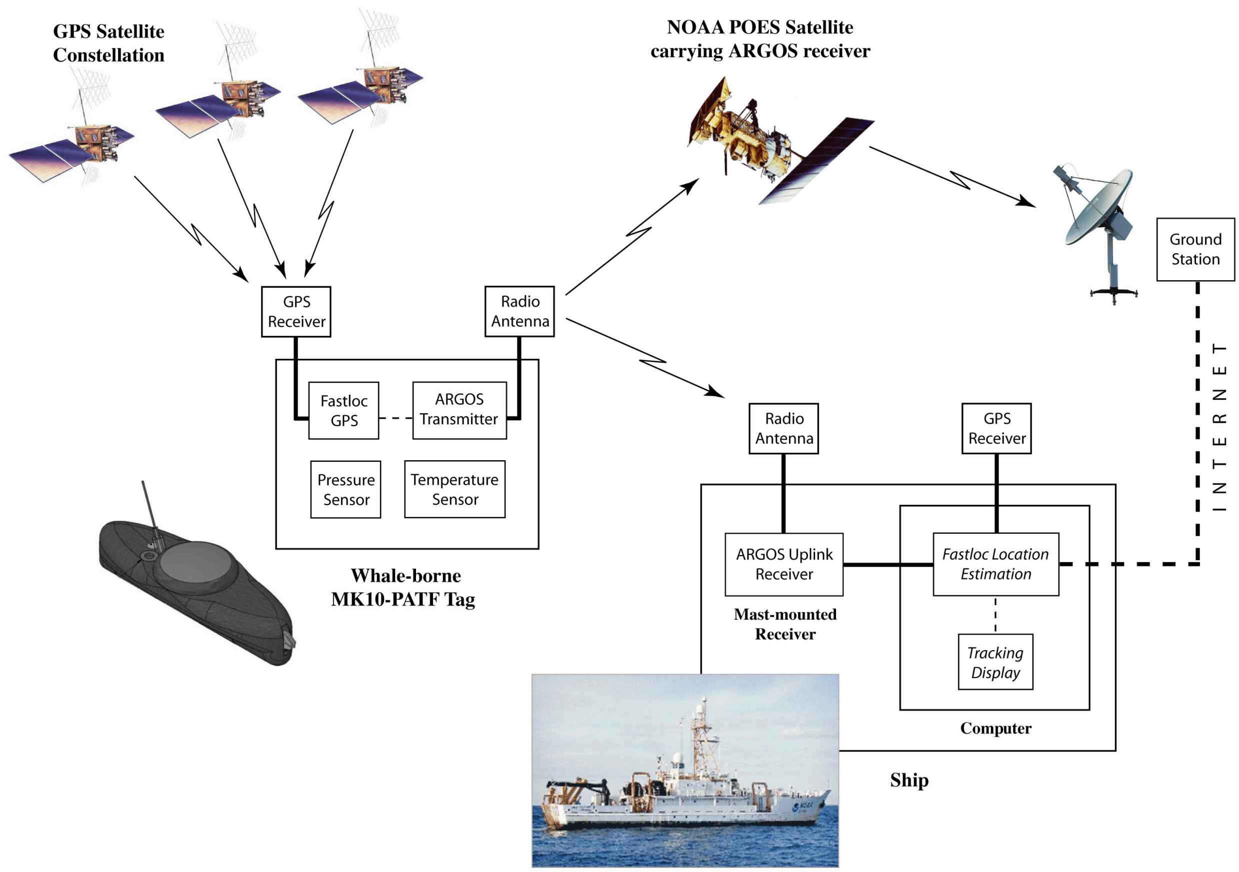

Figure 1. Block diagram of tracking system based on whale-borne Wildlife Computers MK10-PATF tag and shipboard ARGOS receiving system. Fastloc GPS data is telemetered via an ARGOS transmitter from the tag to a local receiver mounted on a nearby ship's mast. The location of the tag is computed from the received Fastloc data and GPS satellite ephemeris data collected with a ship-mounted GPS receiver. In the unlikely event that the ARGOS transmissions from the tag cannot be received locally, Fastloc data from the tag can be acquired through the ARGOS system and relayed via the ship's Internet connection. All location data will be displayed on a chart on the ship's bridge to facilitate tracking.

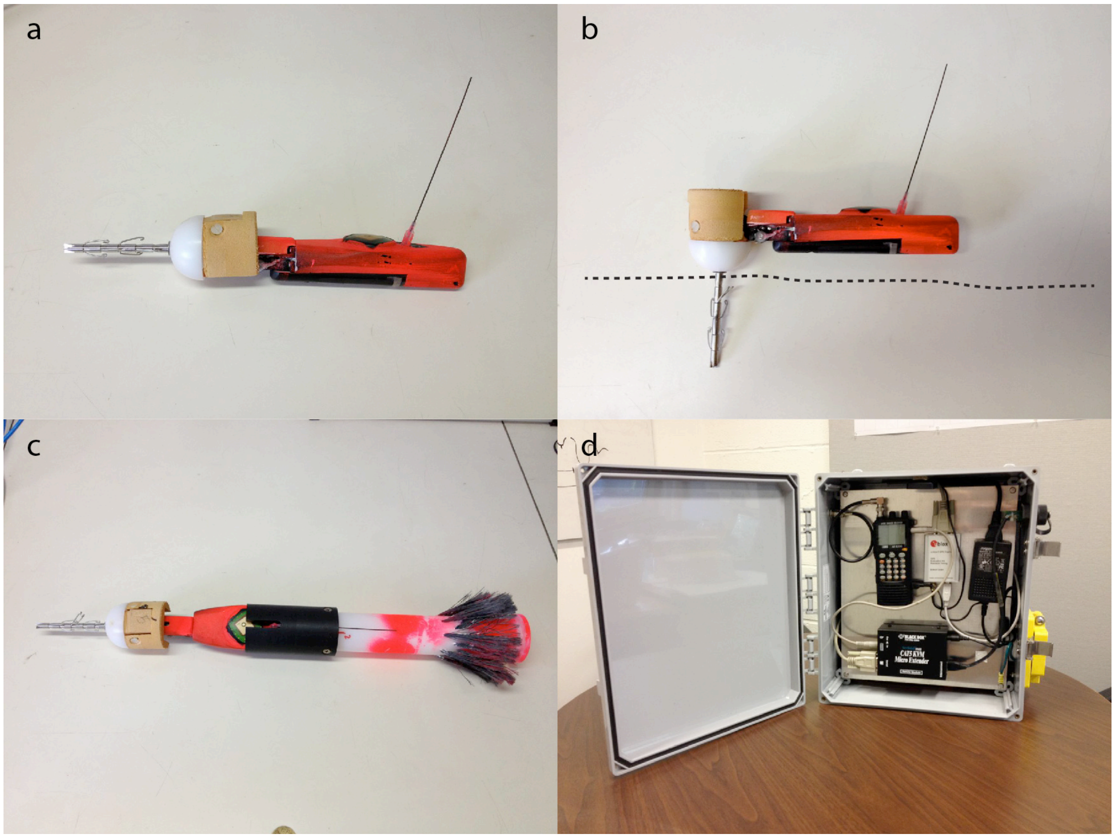

Figure 2. (a) Modified MK10-PATF tag with attachment mechanism (including spring mechanism and dermal anchor with stainless steel pins) cocked for deployment in the compressed-air launcher. (b) Modified MK10-PATF tag with attachment mechanism in articulated position that would occur after attachment to a whale. Dashed line depicts the surface of the whale's skin; note that the tag is designed so that it does not contact the skin. (c) Tag with attached "carrier rocket" ready for loading into the compressed-air launcher (note flu-flu fletching at end of rocket to help the tag fly true in the air prior to attachment). (d) Weatherproof box containing wideband radio receiver, ublox GPS, power supply, and BlackBox KVM extender.